No. 707,716. Patented Aug. 26, 1902.

J. PATTEN.

COMPOUND STEAM ENGINE.

(Application filed July 16, 1901.)

(No Model.) 4 Sheets—Sheet 1.

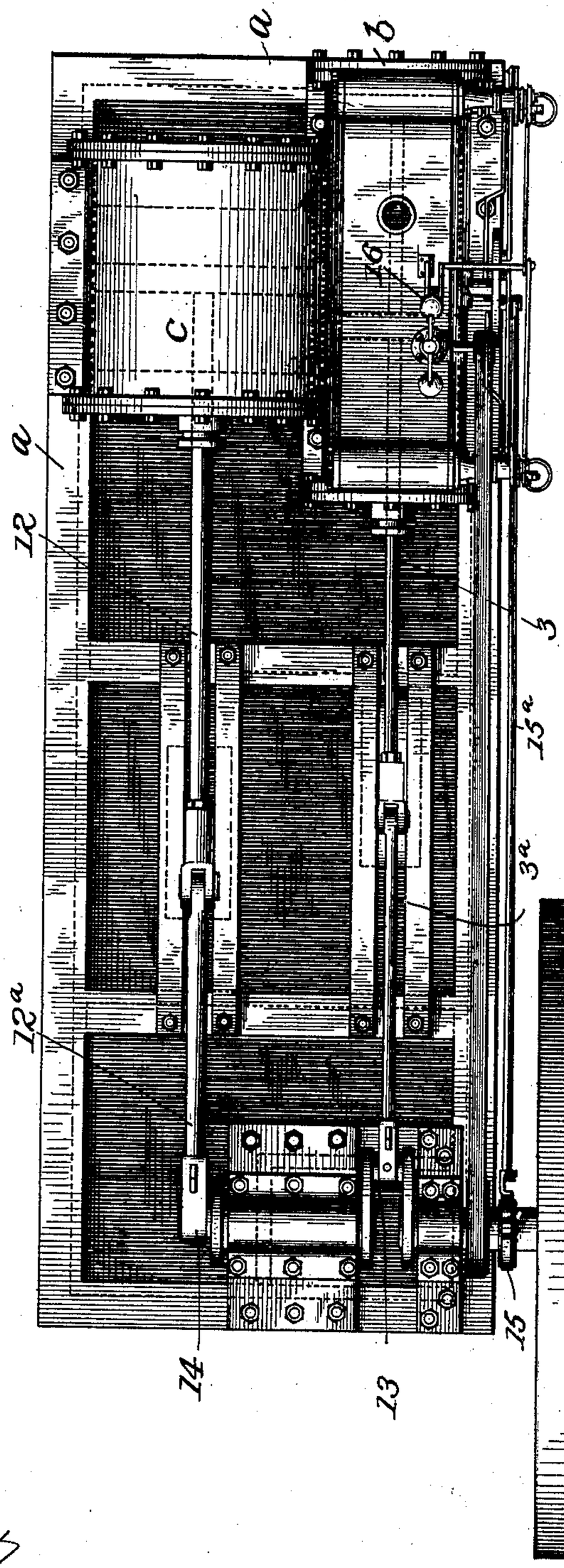

Fig. 1.

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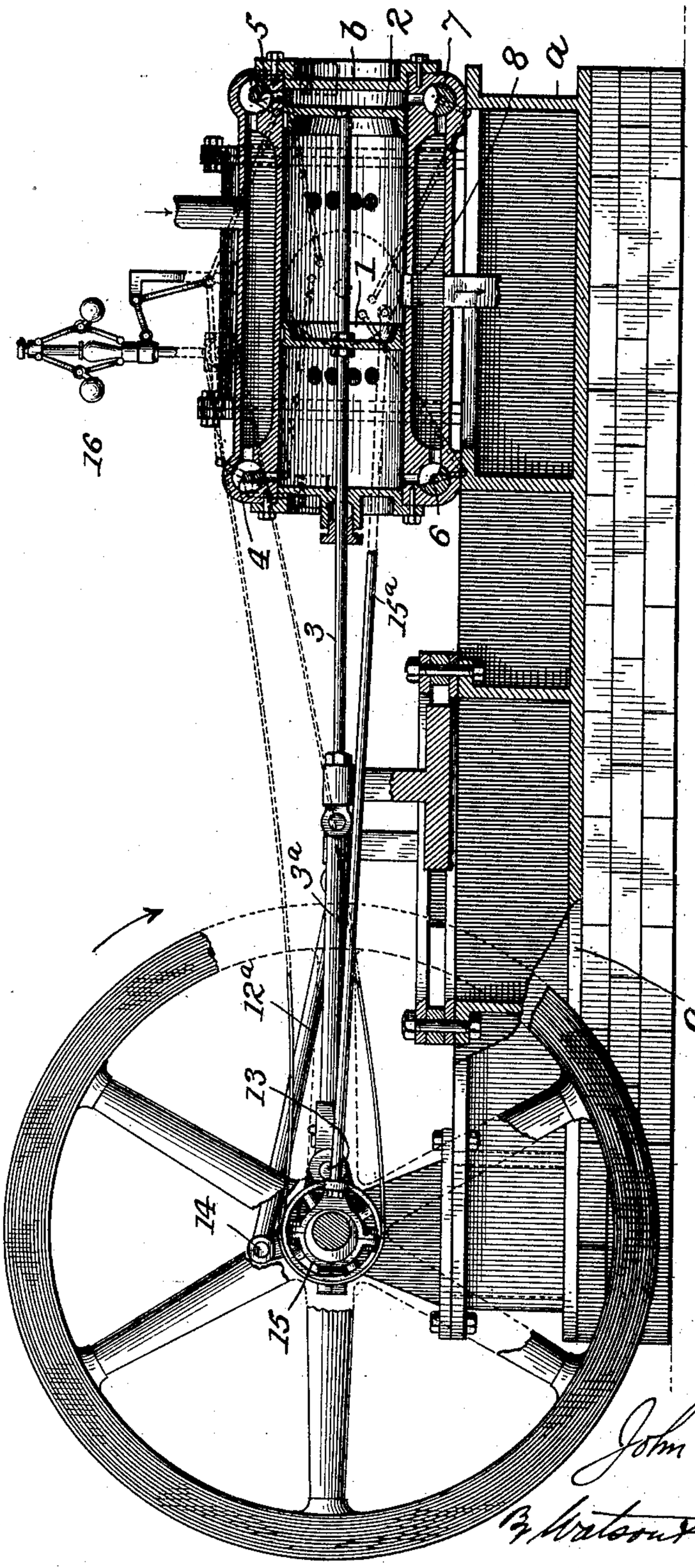

Fig. 2.

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(No Model.) 4 Sheets—Sheet 3.

Fig. 3.

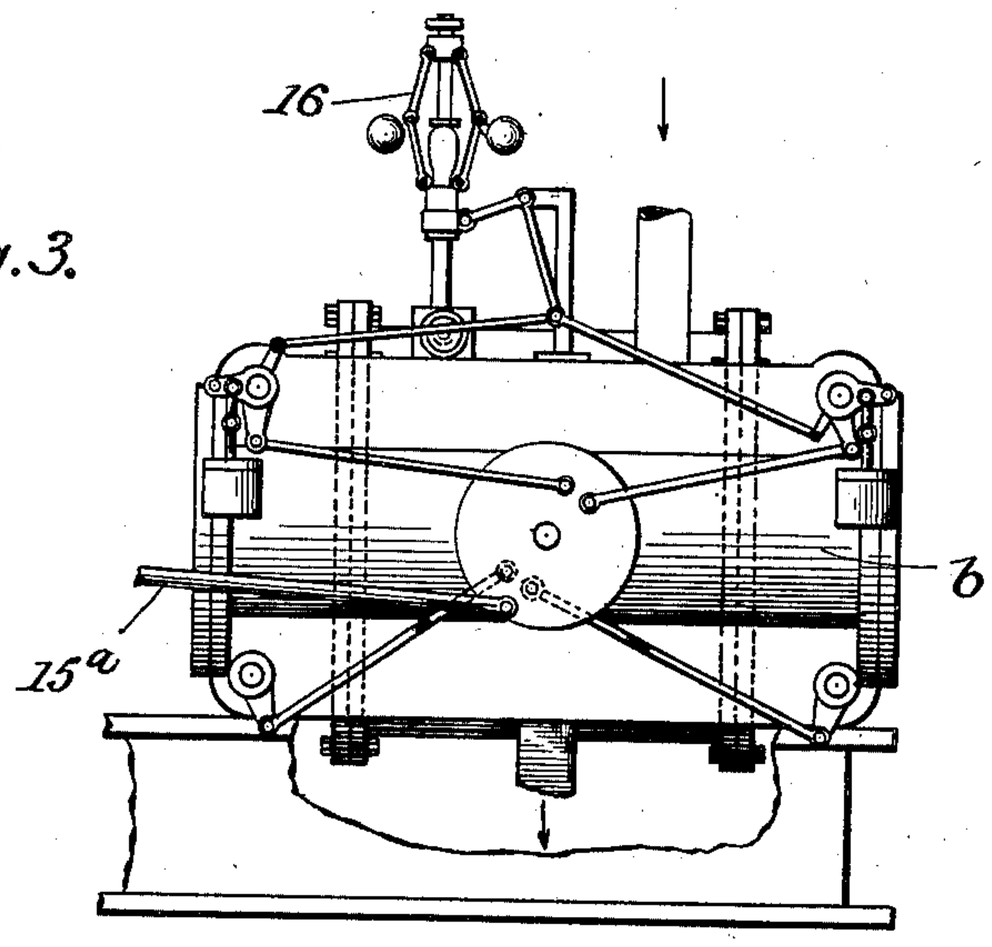


Fig. 4.

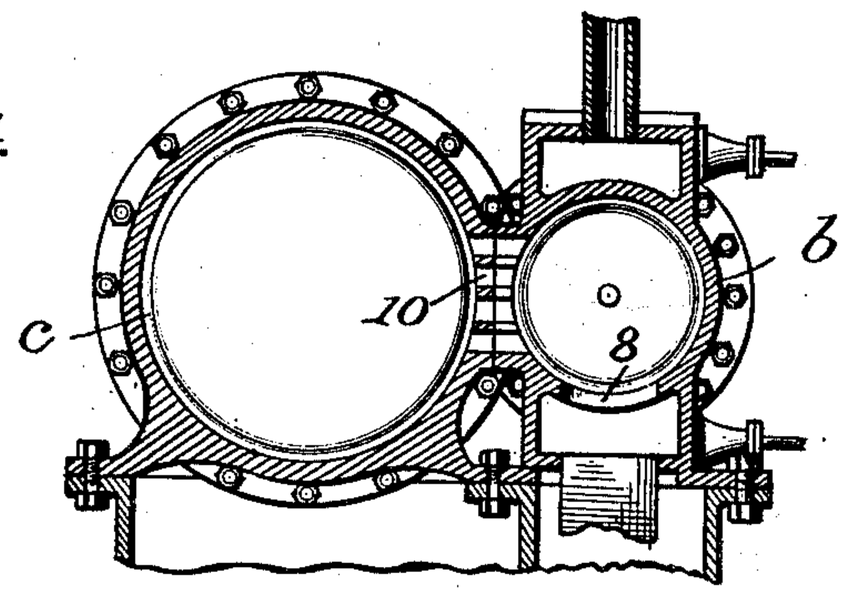
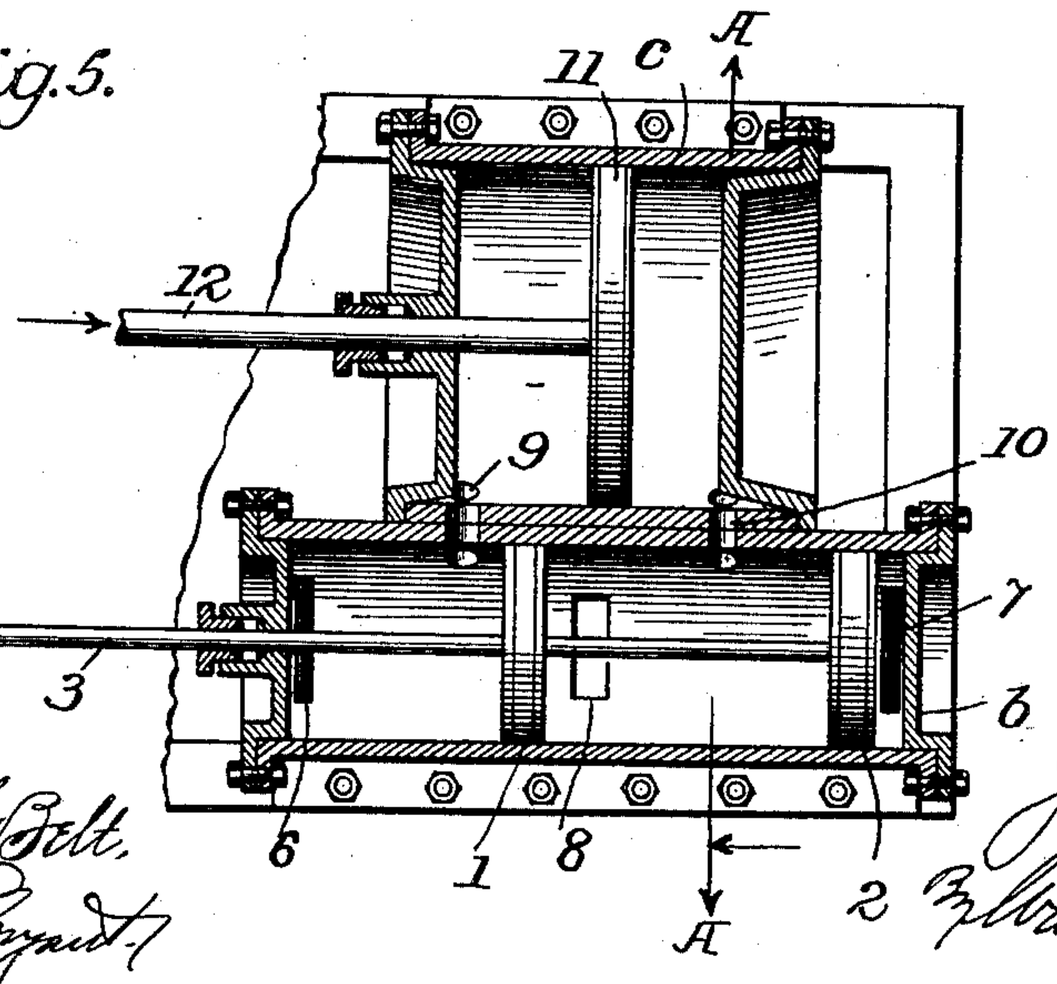


Fig. 5.



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No. 707,716. Patented Aug. 26, 1902.

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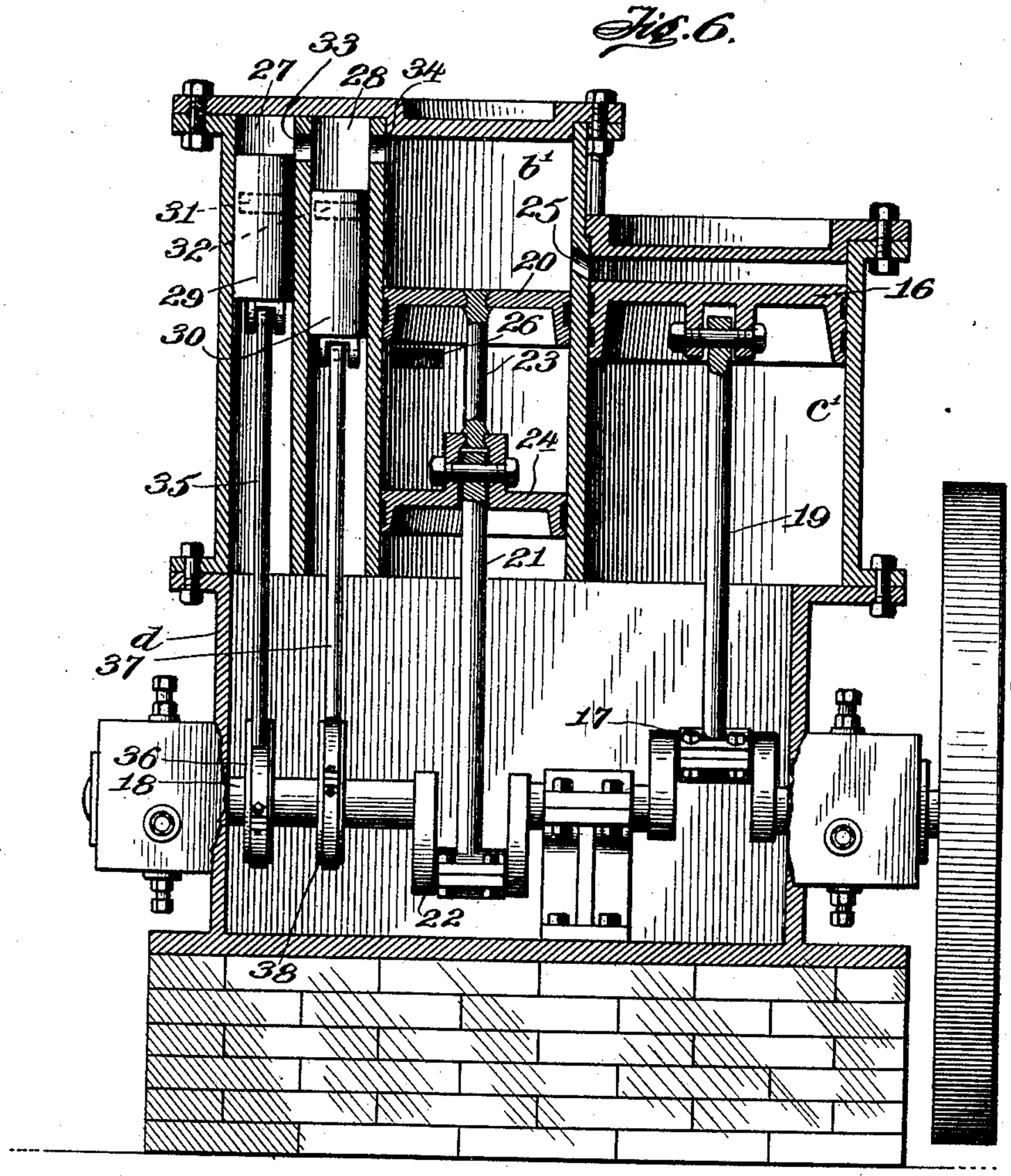
COMPOUND STEAM ENGINE.

(Application filed July 16, 1901.)

(No Model.) 4 Sheets—Sheet 4.

Fig. 6.



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UNITED STATES PATENT OFFICE.

JOHN PATTEN, OF NEW YORK, N. Y.

COMPOUND STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 707,716, dated August 26, 1902.

Application filed July 16, 1901. Serial No. 68,481. (No model.)

To all whom it may concern:

Be it known that I, JOHN PATTEN, a citizen of the United States, residing at New York, in the county of New York, State of New York, have invented certain new and useful Improvements in Compound Steam-Engines, of which the following is a specification.

This invention relates to an improved compound steam-engine in which the piston in the high-pressure cylinder acts as a valve for the low-pressure cylinder. The engine can be made either single or double acting. In the accompanying drawings the invention is illustrated in both single and double acting engines, the cranks being set about one hundred and twelve degrees apart; but the angle between the cranks may vary from ninety to about one hundred and thirty degrees, according to the performance required of the engine.

In the drawings, Figure 1 is a plan view of a double-acting engine complete, the pistons being shown in dotted lines. Fig. 2 is a side elevation of the same, partly in section, the section being taken centrally of the high-pressure cylinder. Fig. 3 is a side view of the cylinders, showing the valve-gear for the high-pressure cylinder. Fig. 4 is a section on the line A A of Fig. 5. Fig. 5 is a horizontal section through the cylinders, and Fig. 6 is a central section through a vertical single-acting engine embodying the invention.

Referring to Figs. 1 to 5, inclusive, of the drawings, which show a double-acting engine, *a* indicates a bed-plate upon which are mounted the high and low pressure cylinders *b* and *c* and the other usual working parts of the engine. The high-pressure cylinder, as shown, is about twice as long as the low-pressure cylinder and contains two pistons 1 and 2, which are secured to the piston-rod 3. At the opposite ends of the high-pressure cylinder are steam inlet and exhaust ports controlled by a valve-gearing of usual construction. In the drawings this gearing is of the Corliss type, and steam is admitted to the high-pressure cylinder through ports 4 and 5 and exhausted through ports 6 and 7, said ports being arranged at the opposite ends of the cylinder. An exhaust-port 8 is arranged in the center of the high-pressure cylinder, and the piston 1 travels between this port and the left-hand end of the cylinder, while the piston 2 travels between said port and the right-hand end of the cylinder. The low-pressure cylinder *c*, as shown, is arranged at the side of the high-pressure cylinder, and ports 9 and 10 at the opposite ends of the cylinder *c* communicate directly with the interior of the high-pressure cylinder *b*. A piston 11 is arranged in the low-pressure cylinder upon a piston-rod 12, and the piston-rods 3 and 12 are connected to the engine-shaft by cranks 13 and 14, respectively, and suitable connecting-rods 3^a and 12^a, said cranks being in the present instance arranged at an angle of about one hundred and twelve degrees apart. This angle may, as previously stated, be varied from ninety degrees to about one hundred and thirty degrees. The valve-gearing is operated in the usual manner by means of an eccentric 15 and rod 15^a, and the point of cut-off is regulated by the operation of a centrifugal governor 16. As the Corliss valve mechanism is well known, a detailed description of it is unnecessary. It will be seen that with this construction the pistons in the high-pressure cylinder which sweep past the ports 9 and 10 will control the admission of steam to the low-pressure cylinder as well as the exhaust therefrom.

The operation is as follows: When the engine is turning in the direction indicated by the arrow and the pistons in the high-pressure cylinder are at the end of the rearward stroke and nearly stationary, the low-pressure piston, owing to the angular relation of the cranks, will be moving rapidly to the rear. In this position of the parts (shown in Fig. 5) the rear end of the low-pressure cylinder is in communication with the exhaust-port 8 through the port 10 and the space between the pistons 1 and 2, while the steam from the forward end of the high-pressure cylinder expands through the port 9 into the low-pressure cylinder against the forward side of the piston 11 and drives the latter rearwardly. Steam is then admitted through the steam-port 5 behind the high-pressure piston 2, and the latter, with the rod 3 and piston 1, move

forward, the steam being automatically cut off at the proper time by the governor. When the piston 1 in its forward movement passes the port 9, the low-pressure piston is at the rear end of its cylinder and the steam from the forward side of the low-pressure piston passes out through the port 9 and the space between the pistons 1 and 2 to the exhaust-port 8. At the same time the exhaust-port 6 in the high-pressure cylinder is opened and the steam in advance of the piston 1 passes through said port. When the crank 14 is past the rear dead-center and the low-pressure piston is about to move forward, the piston 2 will have passed the port 10 and the steam from the rear of the piston 2 will expand through said port into the low-pressure cylinder in the rear of the piston 11. The pistons in both cylinders will then for a time be moving in the same direction, the high-pressure pistons being near the completion of the forward stroke while the low-pressure piston is starting on the forward stroke. The low-pressure piston will move through the greater part of its forward stroke while the high-pressure pistons are moving slowly, completing the forward stroke and starting on the return stroke, owing to the angular relation of the cranks, and hence there will be but little back pressure on the piston 2. Steam is then admitted through the port 4 to the forward side of the high-pressure piston 1 and automatically cut off at the proper time. As the low-pressure piston completes its forward stroke the piston 2 in its rearward movement passes the port 10, permitting the steam from the rear end of the low-pressure cylinder to pass through said port and out through the exhaust-opening 8. The exhaust-port 7 opens at the same time to relieve the pressure from the rear of the piston 2, and the piston 1 passes the port 9 and permits the steam from the forward end of the high-pressure cylinder to expand into the forward end of the low-pressure cylinder just as the piston in said latter cylinder is in position to commence its rearward stroke. This cycle of operations will be repeated continuously as long as steam is admitted to the engine. If the load upon the engine should be great enough to cause the governor to admit steam to the high-pressure cylinder throughout the greater part of the stroke or until the high-pressure piston which is acted upon passes the communicating port between the high and low pressure cylinders, it will be seen that steam at full boiler-pressure will pass through said port to the low-pressure cylinder, and hence the pistons in both cylinders will be acted upon by steam at boiler-pressure. This action would also occur in engines which are not provided with automatic cut-off devices.

In compound engines of the usual types the steam is admitted into the high-pressure cylinder and expanded therein and is then forced out of the high-pressure cylinder by the return stroke of the piston into the low-pressure cylinder, the high-pressure piston being thereby subjected to back pressure equal to the working pressure of the low-pressure cylinder. In the present invention while the steam is acting upon the low-pressure piston the high-pressure piston is almost stationary, and there is practically no back pressure upon the high-pressure piston. The single charge of steam which is admitted to the high-pressure cylinder is cut off at the proper point by the operation of the governor and expands in said cylinder, and when the high-pressure piston has completed about two-thirds of its stroke the steam expands through the communicating opening into the low-pressure cylinder. Hence the single charge of steam expands to the volume of both cylinders, and as the back pressure upon the high-pressure piston is eliminated very much more power from the same volume of steam is obtained than in other types of compound engines. The cranks are set at such an angle to one another that the engine will not stop on a dead-center and the engine has about equal starting power in any position. The construction of the engine is simple, and the valves for the low-pressure cylinder are dispensed with, the pistons in the high-pressure cylinder performing that function. In large engines it is desirable to provide the exhaust-valves 6 and 7 for releasing the steam from the ends of the high-pressure cylinder after the pistons have passed the communicating ports; but in smaller engines, if desired, these exhaust-ports 6 and 7 may be omitted, the pistons being allowed to cushion against the steam, which they confine at the ends of the cylinders, and to compress the steam to the boiler-pressure, as is customary in many kinds of steam-engines.

Fig. 6 illustrates the invention applied to a vertical single-acting compound engine. In this figure b' indicates the high-pressure cylinder, c' the low-pressure cylinder, and d the usual casing inclosing the working parts of the engine. The cylinders are provided with heads at their upper ends only, the lower ends communicating with the interior of the casing. Within the low-pressure cylinder is arranged a piston 16, connected to a crank 17 upon the crank-shaft 18 by a rod 19, and the piston 20 of the high-pressure cylinder is connected by means of rod 21 to the crank 22. As in the previously-described engine, the cranks are arranged at an angle of less than one hundred and eighty degrees and preferably between ninety and one hundred and thirty degrees apart. Connected with the piston 20 by a rod 23 is a movable head 24. A communicating opening 25 is formed between the high-pressure cylinder and the upper end of the low-pressure cylinder, and an exhaust-opening 26 is arranged about the center of the high-pressure cylinder. The movable

head 24 in this engine is adapted to prevent the exhaust-steam from the low-pressure cylinder from passing down into the casing and to direct it through the opening 26. At the left of the high-pressure cylinder are shown two cylindrical guideways 27 and 28, within which are arranged the inlet and exhaust valves 29 and 30, which control the steam admission and exhaust ports 31 and 32, respectively, for the high-pressure cylinder. These exhaust-ports are shown in dotted lines at the back of the valves. An opening 33 connects said guideways at their upper ends, and an opening 34 connects the upper end of the guideway 28 with the upper end of the high-pressure cylinder *b'*. The lower ends of the guideways communicate with the interior of the casing *d*. The steam-inlet valve 31 is actuated by a rod 35, operated from an eccentric 36 upon the main shaft, said eccentric being set about forty degrees in advance of the crank 22, which is connected to the high-pressure piston. The exhaust-valve 30 is actuated by a rod 37, which is operated by an eccentric 38 upon the crank-shaft, said eccentric being set at an angle of about forty degrees behind the crank-pin 22. In operation when the steam-valve 29 moves downwardly far enough to uncover the port 31 steam enters the high-pressure cylinder through ports or openings 33 and 34. The steam thus admitted drives the piston 20 downward, and the steam-valve 29 closes the port 31 before the piston passes the port 25. As the piston 20 passes the port 25 the low-pressure piston 16 is at the commencement of its stroke, and the steam expanding through port 25 acts upon said low-pressure piston. While the high-pressure piston is nearing the end of the downward stroke and starting on the upward stroke, the low-pressure piston moves through the greater part of its downward stroke. When the high-pressure piston in its upward stroke passes the port 25, the steam from the low-pressure cylinder passes through said port and the space between the piston 20 and head 24 and passes out through the exhaust-port 26. The exhaust-valve 30 then opens the port 32, permitting steam from the upper end of the high-pressure cylinder to escape therethrough. It will be evident that this operation will be continuously repeated as long as steam is admitted to the engine.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a compound steam-engine the combination of a high-pressure cylinder having a valve-controlled steam-inlet port at one end and a central exhaust-port, a low-pressure cylinder having a port at one end communicating with the high-pressure cylinder between the steam inlet and exhaust ports of the latter, a piston within the low-pressure cylinder and a pair of connected piston-heads in the high-pressure cylinder, one of said heads being movable between said steam and exhaust ports and adapted to pass beyond the port communicating with the low-pressure cylinder in each direction of its movement, thereby connecting said communicating port alternately with the steam-space of the high-pressure cylinder and with the exhaust-port, and the other head being movable between the exhaust-port and the opposite end of the cylinder.

2. In a compound steam-engine the combination of a high-pressure cylinder having a valve-controlled steam-inlet port at one end and a central exhaust-port, a low-pressure cylinder having a port at one end communicating with the high-pressure cylinder between the steam inlet and exhaust ports of the latter, a piston within the low-pressure cylinder and a pair of connected piston-heads in the high-pressure cylinder, one of said heads being movable between said steam and exhaust ports and adapted to pass beyond the port communicating with the low-pressure cylinder in each direction of its movement, thereby connecting said communicating port alternately with the steam-space of the high-pressure cylinder and with the exhaust-port, and the other head being movable between the exhaust-port and the opposite end of the cylinder, a crank-shaft and cranks to which the pistons in the high and low pressure cylinders are connected, the angular relation of the cranks being less than one hundred and eighty degrees.

3. In a compound steam-engine the combination of a high-pressure cylinder having valve-controlled steam-inlets at both ends and a central exhaust-port, a low-pressure cylinder having ports at both ends communicating with the high-pressure cylinder at opposite sides of said central port, a piston in the low-pressure cylinder movable between the communicating ports and two pistons in the high-pressure cylinder movable across said communicating ports and operating as valves therefor.

4. In a compound steam-engine the combination of a high-pressure cylinder having valve-controlled steam-inlets at both ends and a central exhaust-port, a low-pressure cylinder having ports at both ends communicating with the high-pressure cylinder at opposite sides of said central port, a piston in the low-pressure cylinder movable between the communicating ports, two pistons in the high-pressure cylinder each movable across one of said communicating ports, a crank-shaft, and cranks to which said pistons are connected, the angular relation of the cranks being less than one hundred and eighty degrees.

5. In a compound steam-engine the combination of a high-pressure cylinder having valve-controlled steam-inlet ports at both

ends and a central exhaust-port, a low-pressure cylinder having ports at both ends communicating with the high-pressure cylinder at opposite sides of said exhaust-port, a piston in said low-pressure cylinder, and two connected pistons in the high-pressure cylinder on opposite sides of said exhaust-port, each piston in the high-pressure cylinder being movable across one of said communicating ports and operating as a valve therefor.

In testimony whereof I affix my signature in presence of two witnesses.

JOHN PATTEN.

Witnesses:
HARRY W. HAHN,
F. S. BELT.